

F.T.U.O.

Section 19

INU, GPS, and Integrated INU-GPS Navigation

19.1 NAVIGATIONAL SYSTEM OVERVIEW

Five independent navigational selections for the pilot's and copilot's steering functions are provided. The normal navigational selections are GPS, INU1, INU1/GPS, INU2, and INU2/GPS. If a pilot selects INU3 as the attitude and navigational source using the external auxiliary selector, then INU3 replaces INU1 or INU2 as a selectable navigational source.

The fundamental difference between the INU

solutions and the INU/GPS solutions following loss of GPS information (INU/---) is that the INU outputs in the INU/--- solution are corrected with the Kalman Filter estimated INU "real time" drift errors computed while GPS data was available, resulting in a more accurate navigational solution than the INU alone would provide.

The navigational sources being used for the pilot's and copilot's steering are indicated on the Pilot and Copilot Lateral Steering Pages as shown in Figure 82.

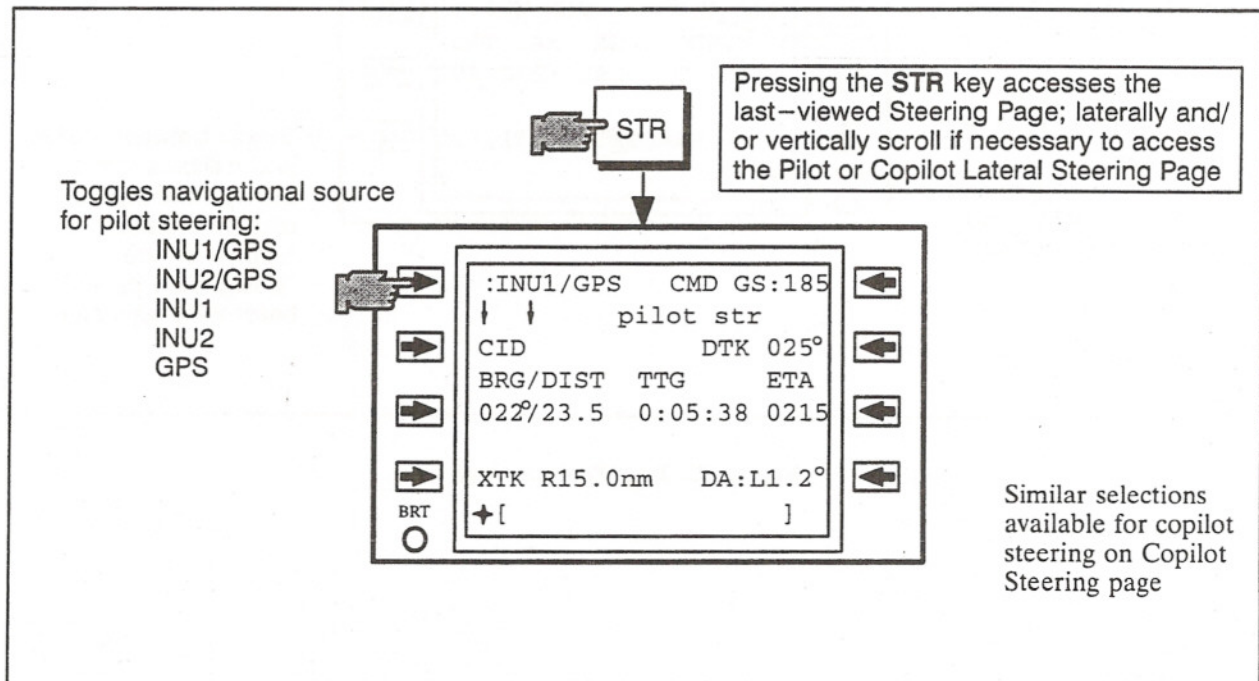


Figure 82 Pilot Lateral Steering and Steer Select Pages

19.2 POSITION, TRACK, AND AIR DATA DISPLAYS

The steering selections determine the sources of the data for the Pilot and Copilot Position Pages shown in Figure 83. The air data shown on these pages comes from the central air data computers CADC1 or CADC2. The baroset input sets the local barometric pressure for VNAV enroute, terminal, and approach

guidance.

The wind vector can be displayed as a current wind vector, crosswind component, or head/tail wind component.

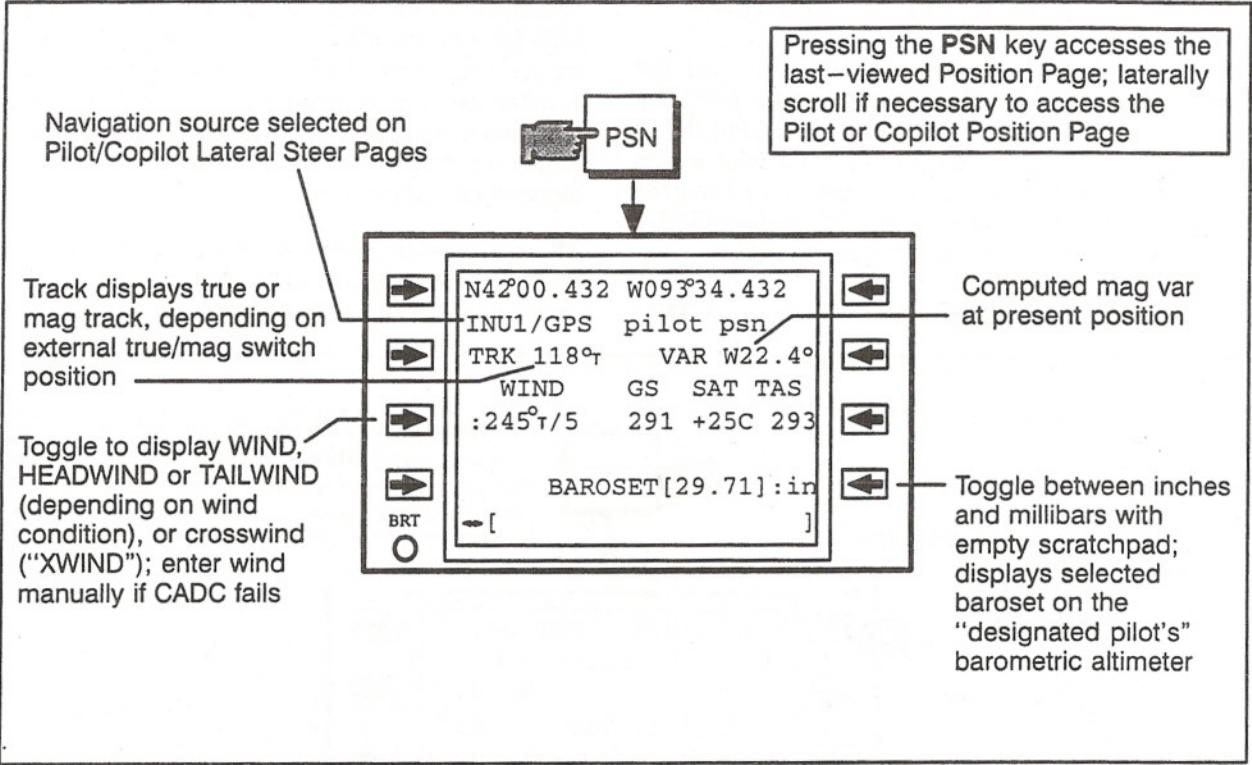


Figure 83 Pilot Position Page

Table 5 Display of Navigation Mode on Position Pages

<i>Selected Mode</i>	<i>Displayed Mode</i>	<i>Conditions for Display</i>
INU1/GPS	INU1/GPS	INU1 and GPS are being used in the INU1/GPS integrated solution
INU1/GPS	INU1/---	GPS is not being incorporated into the INU1/GPS integrated solution
INU1/GPS	---1/---	INU1 navigation data is invalid
INU2/GPS	INU2/GPS	INU2 and GPS are being used in the INU2/GPS integrated solution
INU2/GPS	INU2/---	GPS is not being incorporated into the INU2/GPS integrated solution
INU2/GPS	---2/---	INU2 navigation data is invalid
INU1	INU1	INU1 navigation data is valid
INU1	---1	INU1 navigation data is invalid
INU2	INU2	INU2 navigation data is valid
INU2	---2	INU2 navigation data is invalid
GPS	GPS/A/H	GPS navigation data is smoothed with airspeed and heading
GPS	GPS/-/H	GPS navigation data is being smoothed with GPS ground speed and heading data
GPS	GPS/-/-	GPS is not being smoothed with airspeed and heading data
GPS	---/A/H	GPS is invalid; FMS is dead reckoning with airspeed and heading data
GPS	---/-/-	GPS is invalid
MODEL	MODEL	The model aircraft function is providing the navigation solution. (This function is available only while on the ground.)

19.3 NAVIGATIONAL SOURCE DATA DISPLAYS

Each navigational source (whether selected for pilot/copilot steering or not) has its own Integrated Navigation (INAV) Page to display its current position and navigational status (see Figure 84), not dependent on whether that source is being used as either pilot's steering selection. Table 5 provides a summary of the possible navigation sources that are available and the current status of each source.

19.3.1 INU1/GPS and INU2/GPS Displays

The INU1/GPS and INU2/GPS INAV Pages show the computed present position of those integrated navigation solutions, along with a "95% error" figure of merit for the probable system accuracy given the current INU alignment and GPS satellite navigational quality (see Figure 85). This page also shows the difference between its navigational position and that of the "designated pilot's" selected steering solution (if it is a different source).

If, due to a grossly mis-aligned INU or other anomalous condition, the position shown is incorrect

when compared with the known aircraft position (greater than 100nm), the "INAV RESET" line select key may be used to zero the Kalman Filter error estimates and re-start its process. This action requires confirmation. "INAV RESET" will not degrade normal navigational accuracy, but it will eliminate the benefit of the INU error estimates if GPS data should become unavailable before they can be re-estimated (usually about half an hour after resetting).

If GPS data becomes unavailable en route, the previously-computed INU corrections will continue to be applied to this navigational solution, so it will be more accurate than the uncorrected INU solution. However, to enable the crew to manually update the solution if necessary, the "UPDATE" line select key becomes available and may be used as described in Section 19.4.

Manually remove GPS inputs to an INU/GPS solution by toggling the "GPS" line select key to "OUT". To enable the inputs once again, toggle to "USE".

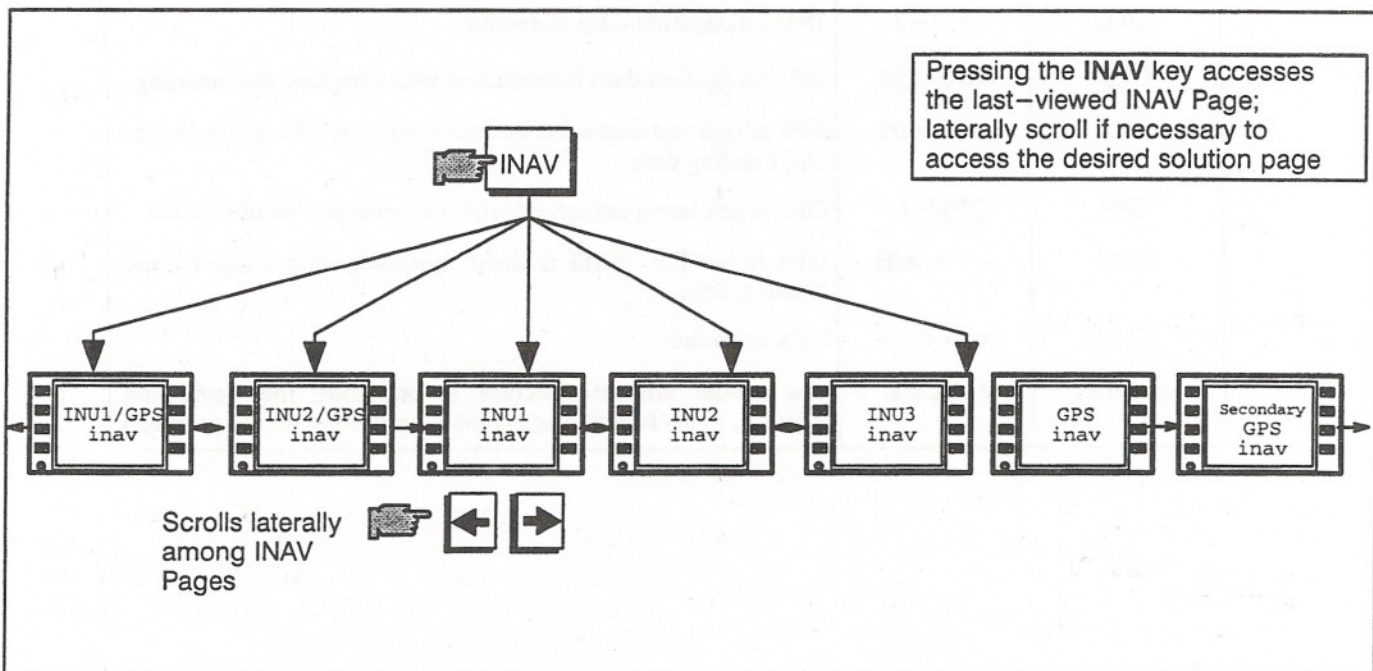


Figure 84 Navigation Source INAV Page Selection

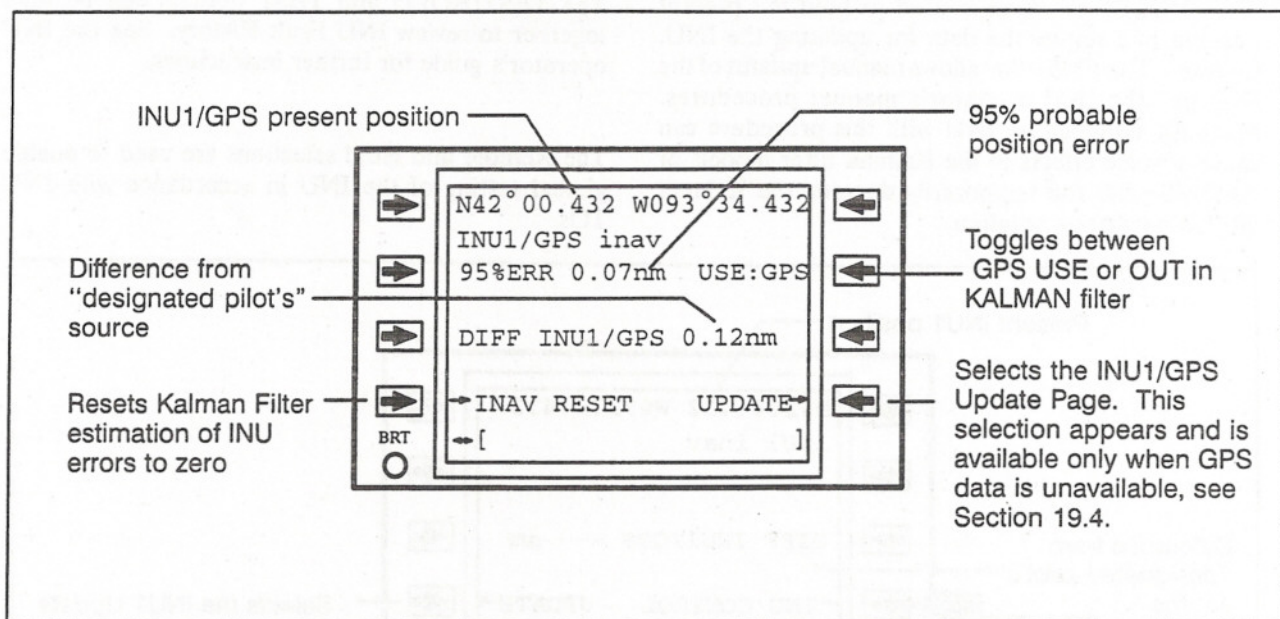


Figure 85 INU/GPS Integrated Navigation Page

19.3.2 INU1, INU2 and INU3 Displays

The INU1 and INU2 and INU3 INAV Pages show the present position from the respective INUs, along with the alignment circular error probable (CEP) (see Figure 86). The current alignment mode is also displayed. The "DIFF" readout shows the difference between the INU position and the "designated pilot's" selected steering solution (if it is a different source).

These pages also provide access to the individual INU control page functions of the Carousel IV INUs, as shown in Figure 86.

Each INU's Control Page may only be accessed from the CDU which directly interfaces with that INU; i.e., INU1 may only be controlled via CDU1, INU2 may only be controlled via CDU2, and INU3 may only be controlled via CDU3. Once a control page has been accessed for an INU, the procedures for initializing, controlling and displaying data for that INU is as described in the Carousel IV operational procedures.

The "DTK-STS" selection is provided to access the INU status codes and enter modes and code data into the INU. Normal entries from the INU operator's guide are provided.

To enable Triple Mix operations, enter "4" and press "INSERT". **Caution:** Triple Mix is a reversionary navigation state that should be used only when GPS data is unavailable. Use of a Triple Mix INU solution

with the GPS integrated solutions can cause unpredictable behavior in the integrated solution. **DO NOT** use Triple Mix modes with the INU/GPS solutions.

To disable Triple Mix operations, enter "5" and press "INSERT".

The "POSITION" selection is provided for entering alignment present position. As a reminder to enter the present position, the annunciation line will display INUx PP (where x = 1, 2, or 3). After selecting the position function, the alignment position is entered, first a latitude, followed by "INSERT", then a longitude, followed by "INSERT". After the INU Mode Select Unit has transitioned to alignment, the current alignment state can be monitored by selecting "DTK-STS".

The "TEST" and AUTO/MAN selections are provided to initiate INU tests and verify proper behavior of the Inertial system. When on the DTK-STS selection, TEST is used to review each of the INU status codes.

The "WAY PT" selection is used to review the pure inertial data prior to disabling Triple Mix operation. To review pure inertial data, press "HOLD", then select the WAY PT toggle selection. Note: True waypoints are entered into the FMS flight plan, not on the INU waypoint list.

The "HDG-DA" selection is used to review the current INU heading and drift angle.

The "HOLD" selection is used to hold the present position and review the data for updating the INU. Caution: The FMS-800 allows manual updates of the INU per the INU operator's manual procedures. Manually updating an INU with this procedure can cause adverse effects to the Kalman filter models of the FMS-800 and temporarily degrade the Kalman filtered navigation solution.

The TEST/HOLD and TEST buttons can be used together to review INU Fault History. See the INU operator's guide for further instructions.

The Remote and Hold selections are used to enable gimbal testing of the INU in accordance with INU TOs.

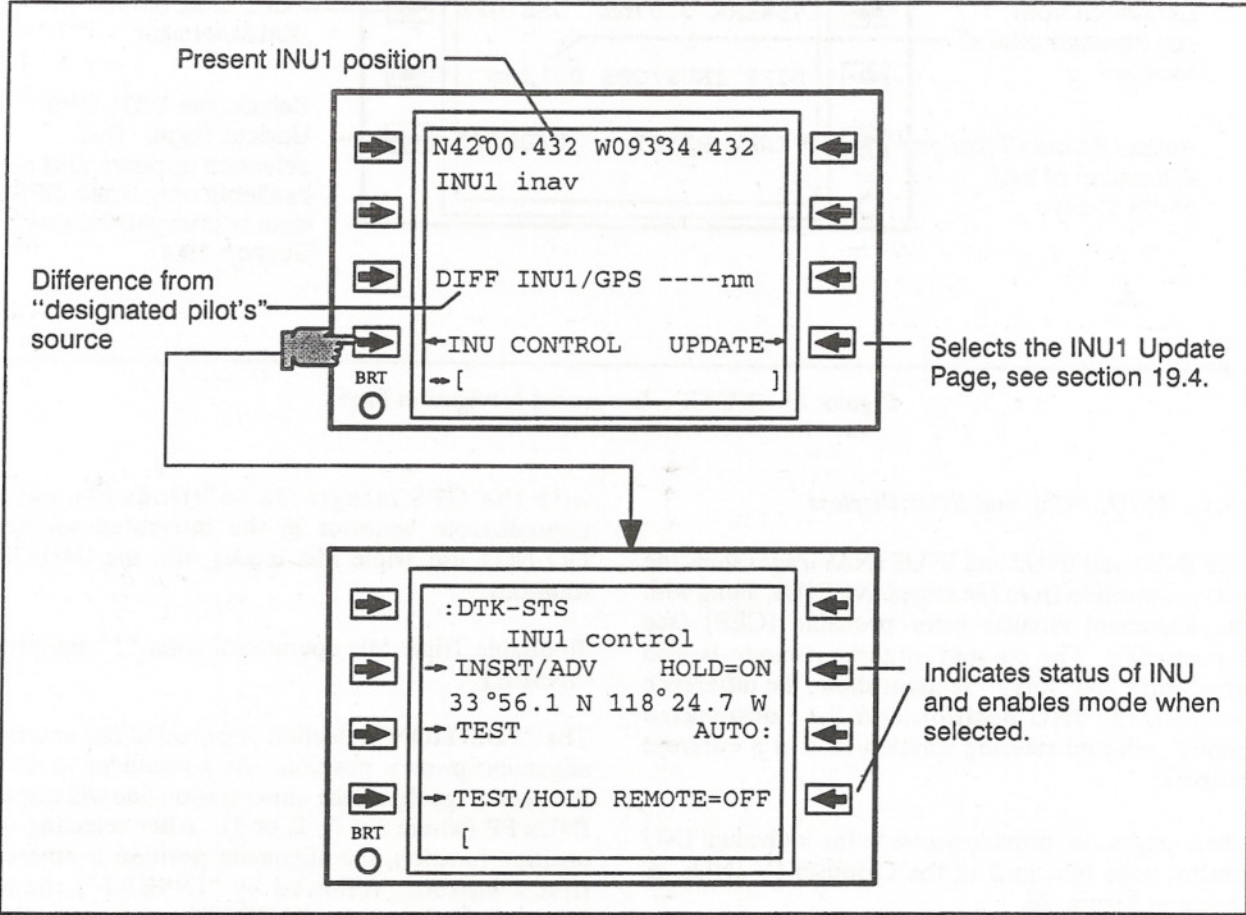


Figure 86 INU Integrated Navigation and Control Pages

19.3.3 GPS Display

The GPS INAV Page shows the present position output from the GPS receiver, along with a "95% error" figure of merit for the probable system accuracy, given the current GPS satellite navigational quality (satellite tracking state and geometry) as shown in Figure 87. If "GPS/A/H" is indicated on the title line, the FMS-800 is using airspeed and heading sensor inputs to smooth the GPS data. This is required to have a valid bank (roll) command output to the flight director and autopilot.

The "MODE" indicates the current GPS receiver tracking/aiding mode: "INIT", "TEST", "NAV/INU", or "NAV/PVA". If in the "NAV/INU" mode, the GPS satellite tracking performance is enhanced over the "NAV/PVA" mode in the presence of jamming and while maneuvering.

The "STATE" indicates the lowest tracking state of the four primary satellite tracking channels: "STATE 1" is acquisition, "STATE 3" is code track only (in jamming) and "STATE 5" is code and carrier lock (no jamming).

The number of satellites being tracked for primary navigational purposes is also indicated; the normal "fully determined" number is 4. Less than 4 may result in GPS data invalidity.

Access the GPS Satellite Data Page to view information on the satellites currently being tracked by the GPS receiver, including satellite vehicle number, signal quality, and state.

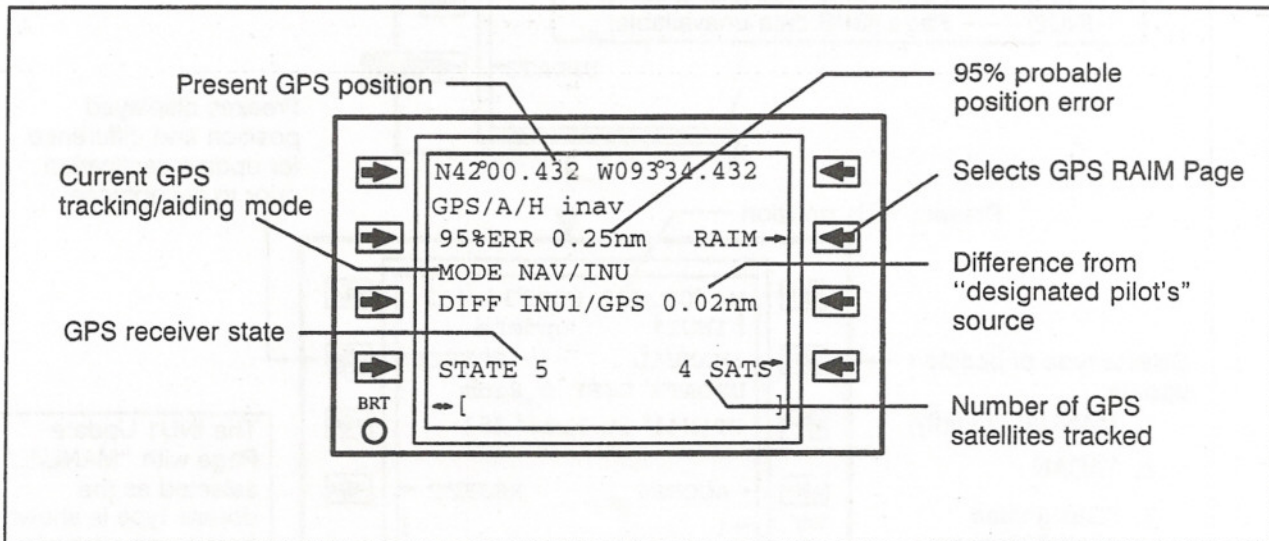


Figure 87 GPS Integrated Navigation Page

19.4 INU AND INTEGRATED NAVIGATIONAL POSITION UPDATES

To update the INUs or the INU-GPS navigational solutions when GPS data is unavailable, select the "UPDATE" line select key on the respective INAV Page (see Figure 88) to access the Update Page. Then select the type of update desired using the left line select key second from the top as shown. The three types of updates are as follows:

1. **MANUAL.** Updates present position (on line 1) to displayed checkpoint ("PT") position on line 5.

2. **TACAN.** Updates present position to the manually entered bearing/slant range position.
3. **INU1/GPS, INU2/GPS, INU1, INU2, or GPS** (whichever is currently selected as the "designated pilot's" steering solution). Updates present position to the displayed navigation solution position.

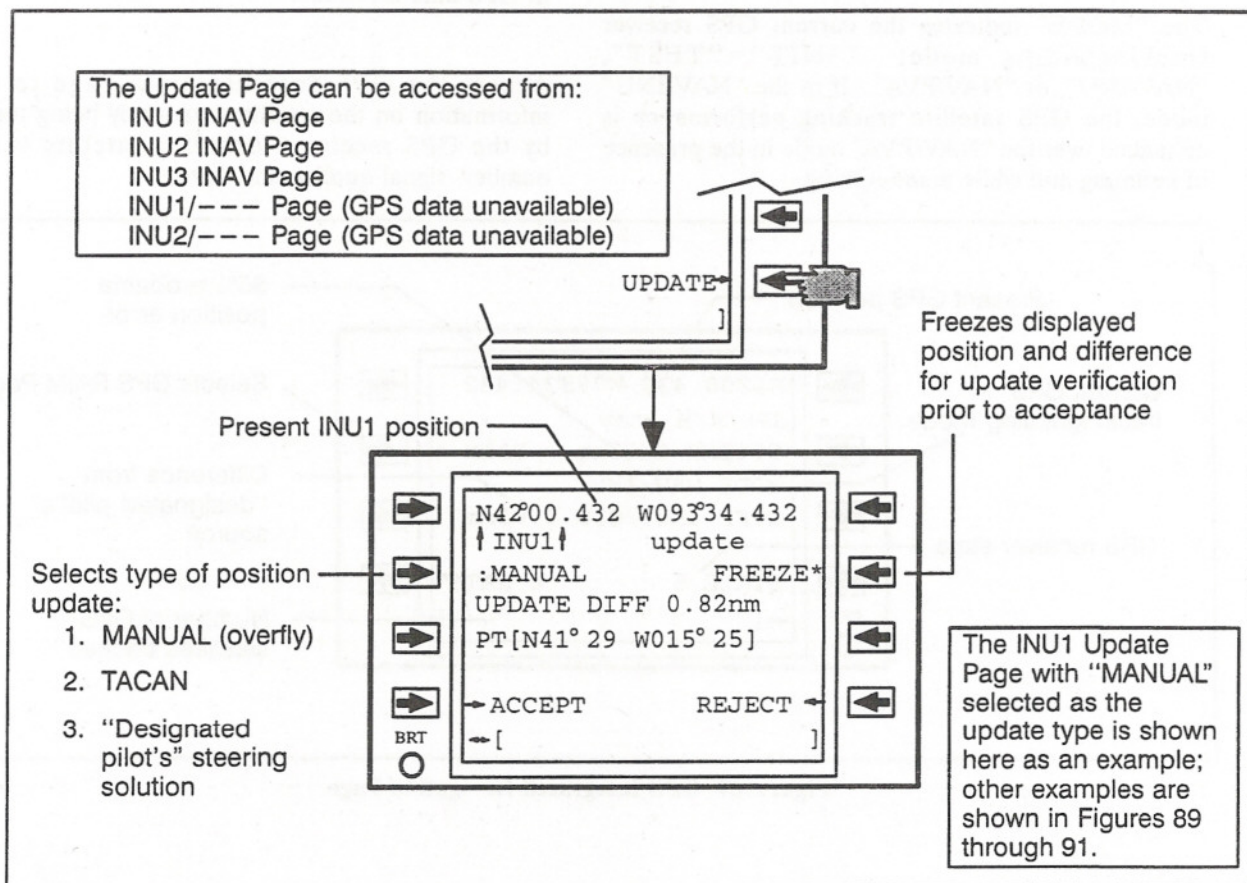


Figure 88 Performing Navigational Position Updates

19.4.1 MANUAL Overfly Updates

To perform a manual overfly update, (1) toggle the left line select key second from the top to "MANUAL" on the Update Page. The "PT" coordinates automatically default to the current active waypoint in the flight plan. (2) If another checkpoint is desired, enter the coordinates, identifier, or identifier/bearing/distance checkpoint as the "PT", as shown in Figure 89. To return to the active waypoint

default, enter a "-" at the "PT" line select key. (3) Freeze the display to review the displayed update difference ("DIFF") for reasonableness by pressing the "FREEZE" line select key. (4) Press the "ACCEPT" line select key to accept the updated position difference correction or the "REJECT" line select key to reject it.

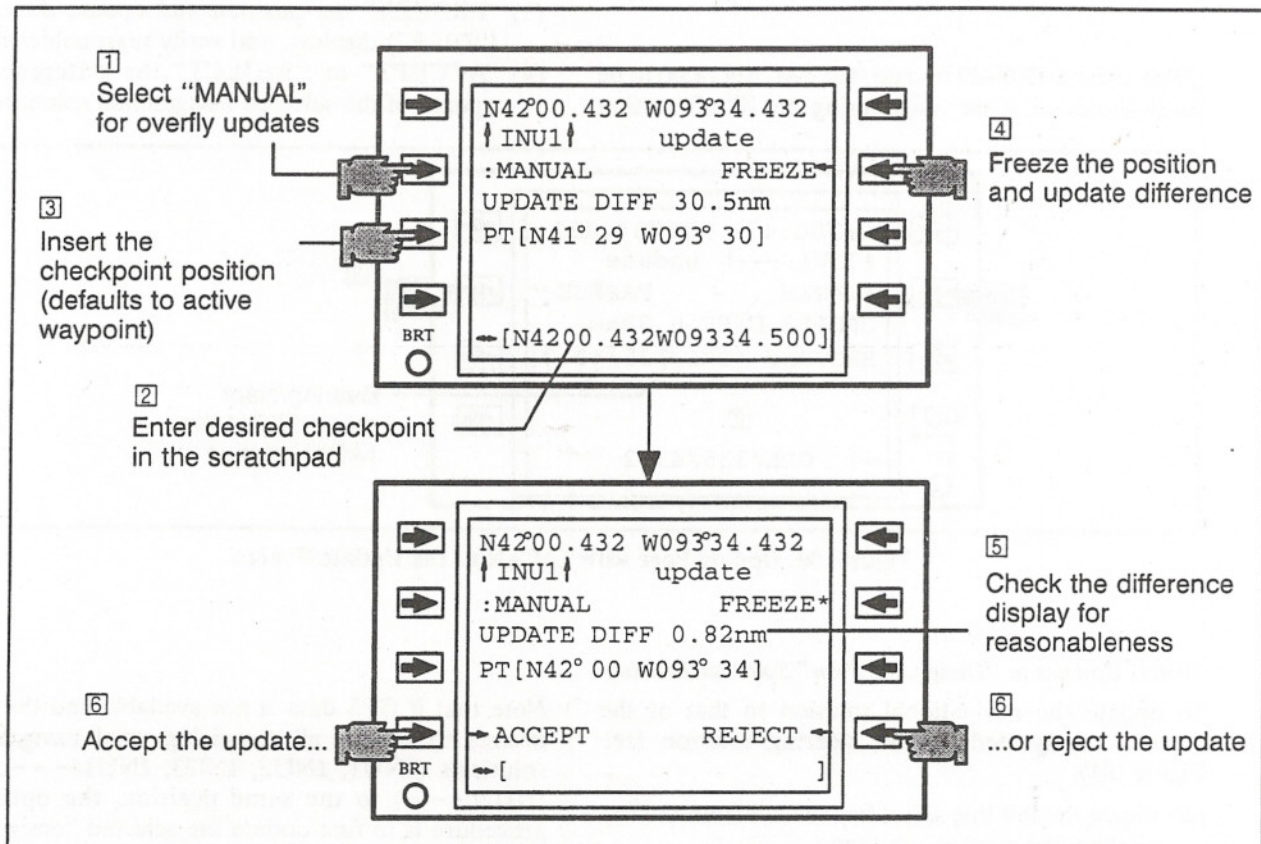


Figure 89 Manual Overfly Position Update

19.4.2 TACAN Updates

TACAN updates provide the ability to update position using radial bearing and slant range data from TACAN or VOR/DME equipment. Given the radial bearing and slant range from the TACAN or VOR/DME and the location of the Navaid station from the ICAO identifier data base, the FMS can compute the present position of the aircraft. This computed position can be used to update the selected navigational solution displayed on the Update Page.

To perform a TACAN update, the TACAN radio to be used should first be tuned using an ICAO station

identifier and the station should be verified to be correct.

On the Update Page (Figure 90),

- (1) Toggle the left line select key second from the top to "TACAN".
- (2) Enter the TACAN bearing/slant range FROM the indicated station as read from the HSI or TACAN bearing indicator.
- (3) "FREEZE" the position and update difference ("DIFF") displays, and verify reasonableness.
- (4) "ACCEPT" or "REJECT" the difference for update of the selected navigational solution.

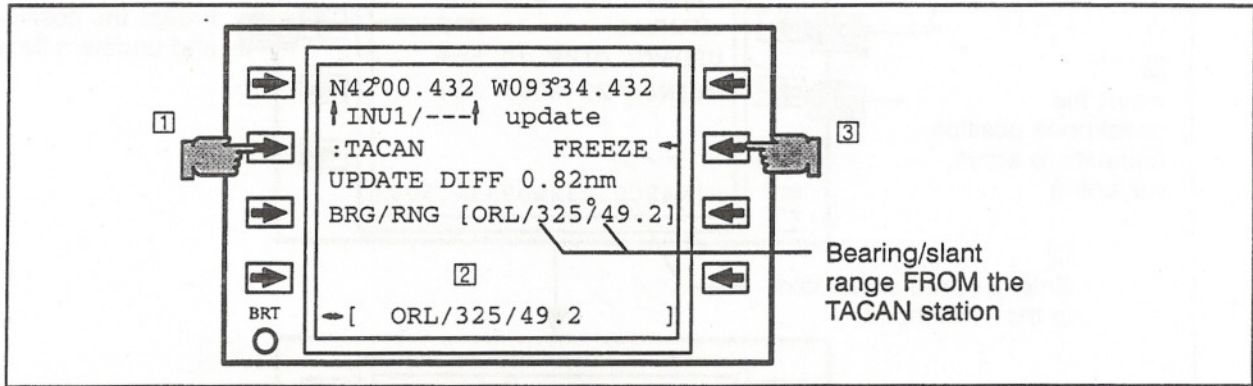


Figure 90 Update Page with TACAN as the Update Source

19.4.3 Updates to "Designated Pilot" Solution Position

To update the navigational solution to that of the current "designated pilot's" steering solution (see Figure 91),

- (1) toggle the left line select key second from the top to show the current solution;
- (2) "FREEZE" the position and update difference ("DIFF") displays;
- (3) verify the reasonableness of the difference displayed;
- (4) "ACCEPT" or "REJECT" the difference correction.

Note that if GPS data is not available and the pilot desires to update all remaining valid navigational solutions (INU1, INU2, INU3, INU1/---, and INU2/---) to the same position, the optimum procedure is to first update the selected "designated pilot" steering solution using a MANUAL, or TACAN update, then update the others individually to that solution. Then, all will be exactly the same immediately thereafter.

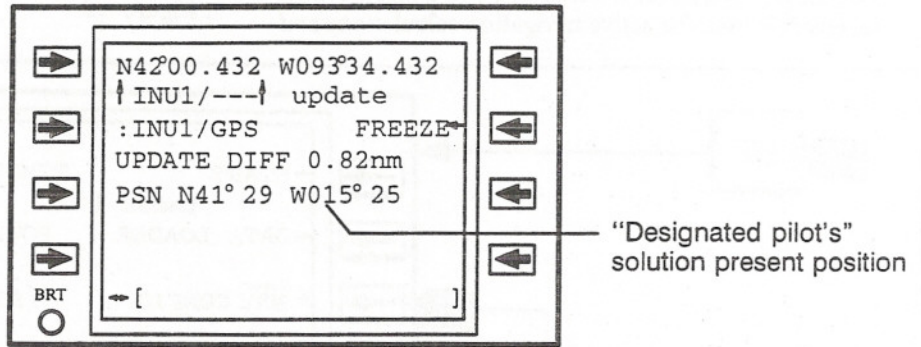


Figure 91 Update Page with "Designated Pilot" as the Update Source

19.5 ACTIVE GPS AND AIDING CONFIGURATION

The crew may control which of the two available GPS receivers is used for active navigation calculations and

Kalman filter INU corrections, through the navigation configuration (NAV CONFIG) page, access as shown in Figure 92.

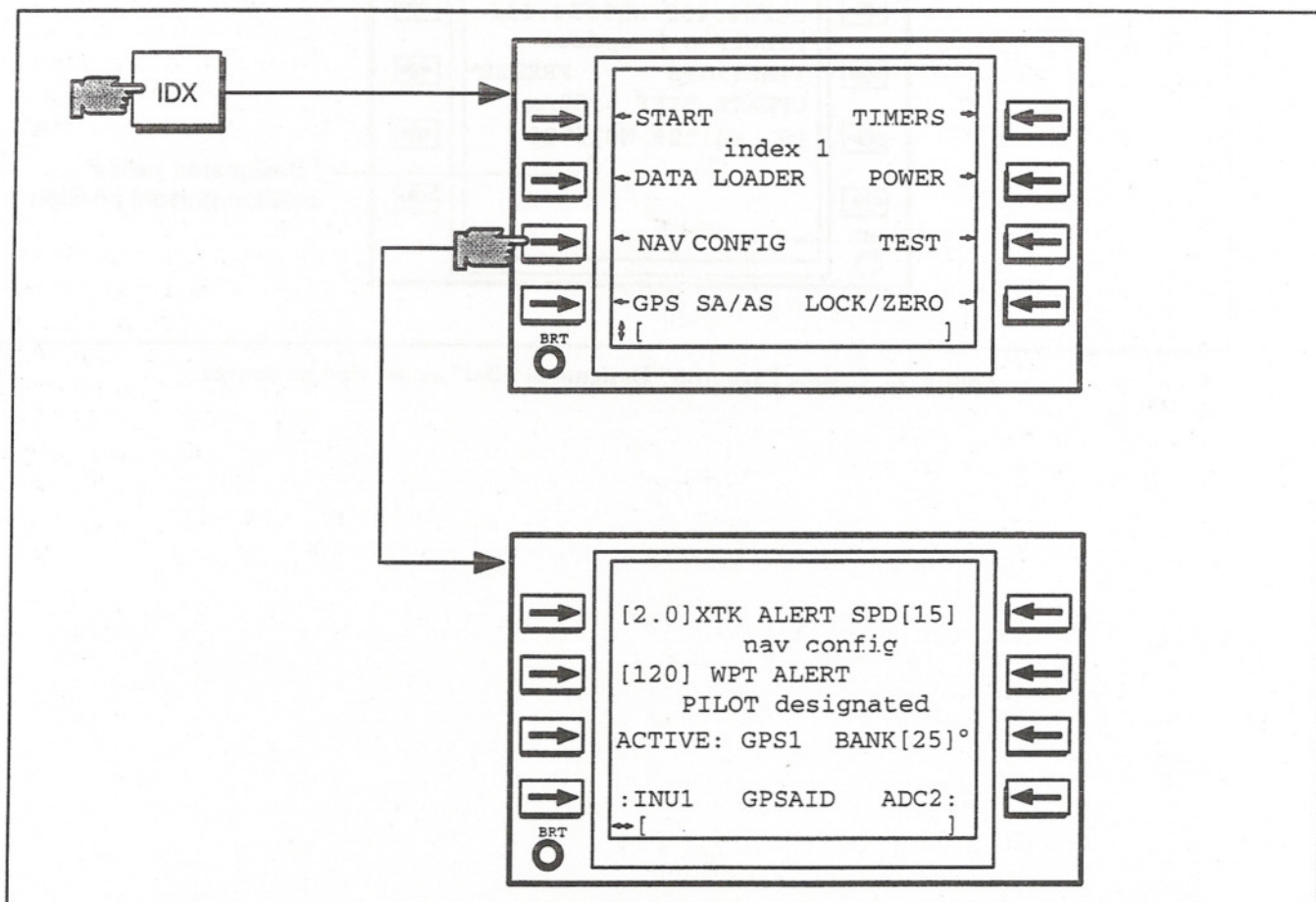


Figure 92 Navigation Configuration Page Access and Usage

Normally, GPS1 should be selected as the Active GPS. Whichever one is selected, the other one will be automatically used as a monitor of the active GPS. If the difference in positions between the two GPS solutions exceeds the integrity limit for the current phase of flight, a "COMPARE GPS" annunciation will be given. If GPS1 fails, GPS2 may be selected as the

active one.

Also on the NAV CONFIG page, the crew may select the INU to be used for velocity aiding of the GPS receivers, and the air data source to be used for altitude aiding. Normally these should be set to INU1 and ADC1 respectively.

19.6 GPS SATELLITE DATA AND RECEIVER AUTONOMOUS INTEGRITY MONITORING (RAIM)

The FMS-800 provides the crew access to pages displaying the individual channel/satellite tracking status for each GPS receiver and the RAIM control/predictive RAIM for the active GPS receiver. These pages are accessed by selecting the related line key on the GPS INAV page as shown in Figure 93.

To request the availability of approach RAIM at a destination airport, first enter the identifier of the airport in the top line of the RAIM/PREDICTION page. Then enter the expected time of arrival (ETA) in UTC. After performing the prediction calculation, the FMS-800 will display the availability of approach RAIM on the page information line. This availability applies to a period from 15 minutes prior to the entered ETA until 15 minutes after the ETA.

The FMS-800 provides an active RAIM solution at present position. By tracking GPS satellite

state-of-health and orbital geometry, the FMS-800 is capable of determining when the GPS navigation solution is degraded or suspect due to satellite failures. If the GPS receiver is unable to provide a RAIM solution due to satellite tracking problems or problems with the satellite constellation geometry, a NO RAIM annunciation and external RAIM alert will be provided to inform the crew of the absence of RAIM protection. During a NO RAIM period, the GPS navigation solution may be acceptable but the integrity of that solution will be indeterminate. During normal GPS navigation with an active RAIM solution, if the GPS receiver determines that there is an inconsistency in the GPS navigation solution, a RAIM WARN annunciation and external RAIM alert will be provided to inform the crew of a degraded GPS navigation solution. When a RAIM WARN is provided, the crew should immediately select a non-GPS based navigation solution on the Lateral Steer page (see Figure 82) until the integrity of the GPS navigation solution is restored.

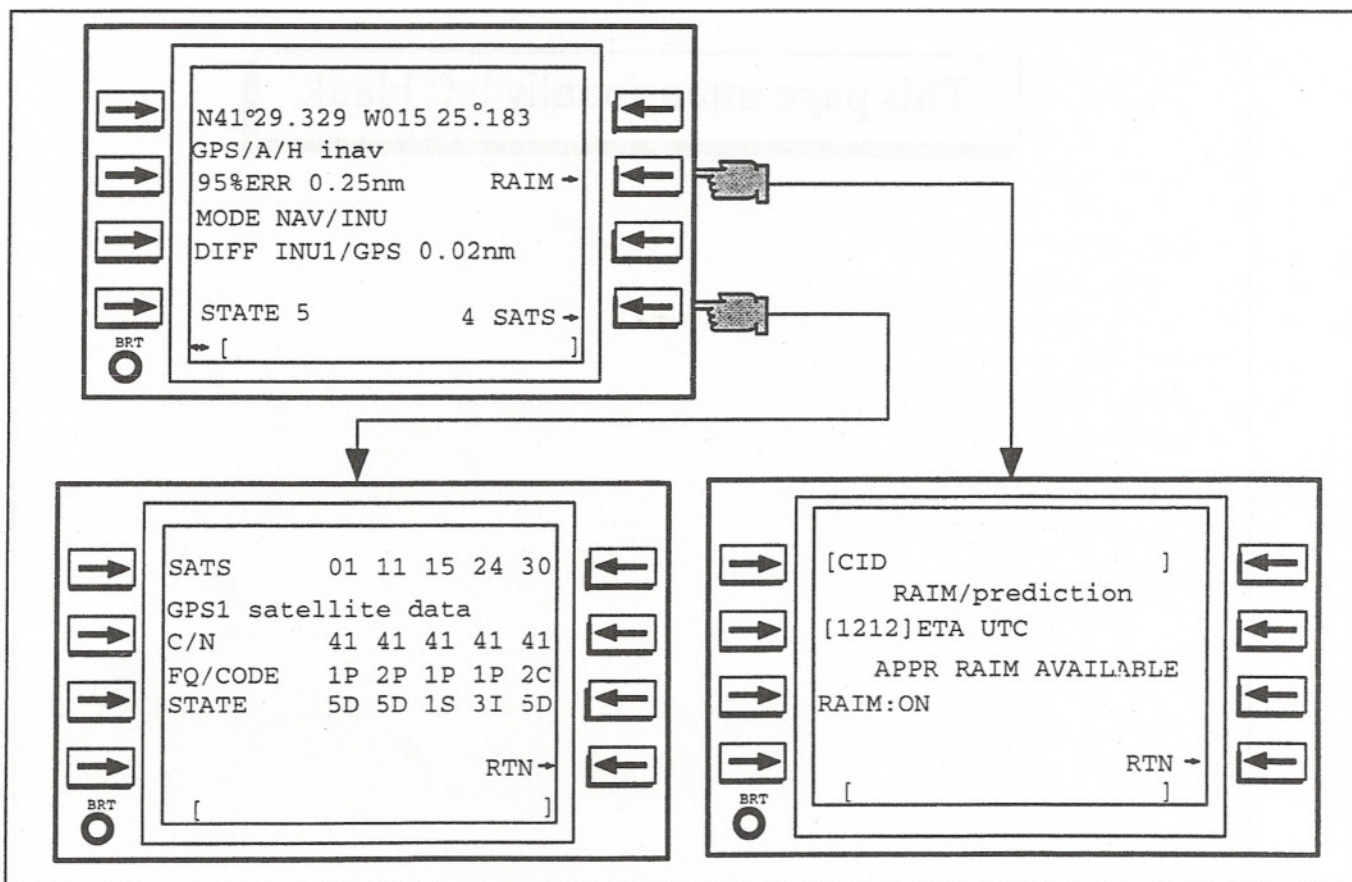


Figure 93 GPS Satellite Data and RAIM Pages

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